STEVAL-BFA001V1B Kit Overview

Setup and programming

Data Monitoring/Logging

How to enable Predictive Maintenance
STEVAL-BFA001V1B Kit Overview
The STEVAL-BFA001V1B is based on 3D digital accelerometer, environmental and acoustic MEMS sensors.

What’s inside?

The STEVAL-BFA001V1B includes:

1. STEVAL-IDP005V1 - industrial sensor board
2. STEVAL-UKI001V1 - Adapter board for ST-LINK/V2-1
3. 0.050" 10-pin flat cable
4. 4-pole cable mount connector plug, with male contacts
5. M12 female connector with 2m cable

Designed for:
- Condition Monitoring (CM)
- Predictive Maintenance (PdM)
Main supply voltage: 18..32V
Main components:
• 32-bit ARM® Cortex®-M4 core for signal processing and analysis (STM32F469AI)
• Sensors:
  • iNEMO 6DoF (ISM330DLC- accelerometer and gyroscope)
  • Absolute Digital Pressure (LPS22HB)
  • Relative Humidity and temperature sensors (HTS221)
  • Digital Microphone sensor (MP34DT05-A)
• IO-Link PHY Device (L6362A)
• EEPROM (M95M01-DF) for data Storage
• Step-down switching regulator and LDO regulator (L6984 and LDK220)
• M12 industrial connector
• SWD connector for debugging and programming capability
• Reset button
• Expansion connector with GPIO, ADC, I²C bus
### Software Overview

#### Demonstrations
- Condition Monitoring
- Predictive Maintenance

#### Applications
- Acoustic Analysis
- Environmental monitoring
- Vibration Analysis

#### Middleware
- Vibration Signal Processing
- Audio Lib

#### Hardware Abstraction
- STM32Cube Hardware Abstraction Layer (HAL)
- Board Support Package

#### Hardware
- ISM330DLC, HTS221, LPS22HB, MP34DT05-A, M95M01-DF
- STEVAL – IDP005V1

### Software Description

Set of firmware examples for CM and PdM based on 3D digital accelerometer (only accelerometer is supported in fw package), environmental and acoustic MEMS sensors.

#### Key features
- Developed for STM32F469AI with easy portability across different MCU families
- Middleware including algorithms for advanced time and frequency domain signal processing for vibration analysis:
  - Programmable FFT size (256, 512, 1024, 2048 points)
  - Programmable FFT overlapping
  - Programmable acquisition time window
  - FFT averaging during acquisition time
  - Programmable windowing (Flat Top, Hanning, Hamming)
  - Speed RMS moving average, acceleration max peak.
- Middleware integrating microphone algorithms for:
  - PDM to PCM
  - Sound pressure
  - Audio FFT
- Environmental, acoustic and vibration data monitoring through freely available terminal emulator.
- Example firmware to communicate with STEVAL-IDP004V1 (IO-Link master capable, multi-port evaluation board) and dedicated PC GUI.
Setup and Programming
Unpack the STEVAL-BFA001V1B ...

1. STEVAL-IDP005V1
2. STEVAL-UKI001V1
3. 10-pin flat cable
4. 4-pole male connector
5. M12 female connector with 2m cable

What else do you need? – not included in the kit –

- Any STM32 nucleo-64 to program, debug and interface with PC
- USB cable Type-A to Mini B
- STEVAL-IDP004V1 Master board and generic RS-485/422 USB adapter (required only to use the GUI)
- Laptop
- Generic power supply (range 18..32V)
STEVAL-IDP005V1 Demo Setup
Software prerequisites

- **STSW-LINK009**
  ST-LINK/V2-1 USB driver

- **STSW-LINK007**
  ST-LINK/V2-1 firmware upgrade

- Common freely **Serial line terminal** (i.e. TeraTerm)

- **ST IDP005V1-GUI** (setup included in \STSW-BFA001V1\Utilities folder)

- **Microsoft.net** version 4.5 or higher (this is only to run the GUI)

- **RS-485/USB adapter driver** (this only to use STEVAL-IDP005V1 connected to IO-Link master capable multi port board)
The STEVAL-IDP005V1 can be powered in two ways:

- Plug the M12 cable onto the STEVAL-IDP005V1 and connect the other end to a power supply 18..32V.

- If available, use the STEVAL-IDP004V1 to supply the STEVAL-IDP005V1 through the M12 cable.
Programming the STEVAL-IDP005V1 1/2

STEVAL-UKI001V1 and ST-LINK/V2-1 overview

1. STM32 NUCLEO-64 comes with ST-LINK/V2-1

2. Make sure that SB12 is open

3. STEVAL-UKI001V1 (top view) has two SWD sockets:
   - 20-pin (100 mils)
   - 10-pin (50 mils)

4. STEVAL-UKI001V1 (bottom view)
Remove all short cap jumpers from the STM32-NUCLEO

Plug the STEVAL-UKI001V1 on the STM32-NUCLEO respecting the CNx ref.

Programming steps:

a. Connect the application board to the ST-LINK/V2-1 via the 10-pin flat cable plugged on J2 (on the STEVAL-UKI001V1), then power-on.

b. Connect the ST-LINK/V2-1 with a PC via an USB cable plugged on CN1.

c. The ST-LINK/V2-1 will be recognized as a removable storage.

d. To download the firmware, simply drag the .bin file onto it.
Data Monitoring / Logging
The STEVAL-IDP005V1 offers applications and examples as detailed below. All projects allow data monitoring through serial terminal with board connected to PC.

Can also work with the STEVAL-IDP004V1 and a dedicated GUI.
STEVAL-IDP005V1 Data Monitoring

STEVAL-IDP005V1 sensor and analysis data can be displayed on a PC in two ways:

- Terminal emulator (TeraTerm or others freely available)
- GUI to be used through the STEVAL-IDP004V1 (multiport Master board)
STEVAL-IDP005V1 Data Monitoring

Setup the terminal emulator

1. Plug the STEVAL-UKI001V1 on the STM32-NUCLEO, then connect to the STEVAL-IDP005V1

2. Open the terminal emulator

3. Push the Reset button on the STEVAL-UKI001V1 (or STEVAL-IDP005V1)

4. Insert the new parameters or press ENTER

5. Press Y to start monitoring

Terminal emulator settings
- Name: COM Port name
- Baud Rate: 230400
- Data: 8
- Parity: None
- Stop Bit: One
- Flow Control: None
STEVAL-IDP005V1 Data Monitoring
Parameter Configuration Details

Odr -> Accelerometer ODR in Hz
fs-> accelerometer full scale in g
Hpf -> accelerometer high pass filter
  0 - HPF_ODR_DIV_4:
  1 - HPF_ODR_DIV_100:
  2 - HPF_ODR_DIV_9:
  3 - HPF_ODR_DIV_400:

Size -> FFT size (256, 512, 1024, 2048)
ovl -> ft overlapping in % (5 ÷ 95)
Tacq -> acquisition time in ms (0.5 ÷ 60000)
Tau -> time constant for RMS in ms
  (25,50,100,150,250,500,1000,1500,2000)
Subrng-> 8, 16, 32, 64 number of spectral subrange
Wind-> 0 (Hanning)
  1 (Hamming)
  2 (Flat Top)
Tdtype -> 0 Speed RMS
  1 Acc RMS
  2 Acc RMS and Speed RMS

STEVAL-IDP005V1 allows data monitoring using the service UART

The CM application allows data plot and vibration parameters setting (only selected parameters can be changed)
### Data Details (1/3)

- **P, T, rH data**
- **RMS for Acc and/or speed**
- **Accelerometer FFT**
- **Accelerometer Spectral frequency subrange and related amplitude**
- **Frequency and time domain vibration data**

#### Table 1: Time Domain Data Table

<table>
<thead>
<tr>
<th>Time</th>
<th>X</th>
<th>Y</th>
<th>Z</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Table 2: FFT Subrange Results on Three Axes X-Y-Z

<table>
<thead>
<tr>
<th>Time</th>
<th>X</th>
<th>Y</th>
<th>Z</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Table 3: FFT Spectral Analysis

<table>
<thead>
<tr>
<th>Time</th>
<th>X</th>
<th>Y</th>
<th>Z</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Table 4: FFT Results

<table>
<thead>
<tr>
<th>Time</th>
<th>X</th>
<th>Y</th>
<th>Z</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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**Note:**
- The tables and data presented are placeholders. Actual data would need to be provided for a complete analysis.
- The images and diagrams illustrate the types of data and analysis that can be performed on the STEVAL-IDP005V1 platform.
### FFT Averaging number. It is a function of overlapping and acquisition time

<table>
<thead>
<tr>
<th>Frequency and max amplitude in subrange on 3 Accelerometer axis</th>
</tr>
</thead>
</table>

### Max Amplitudes

| Xa: 0.065 | Ya: 0.087 | Za: 0.072 |

### Sin Frequencies


### Acceleration Time Domain Max Peak

| Xe: 0.176 | Ye: 0.209 | Ze: 0.152 |
The displayed data can be saved and plotted on an external program (i.e. Excel) For example, the FFT spectral analysis.

**FFT Spectral Analysis**

```

<table>
<thead>
<tr>
<th>Min Freq</th>
<th>X</th>
<th>Y</th>
<th>Z</th>
<th>Amplitude (m/s²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.027</td>
<td>0.010</td>
<td>0.001</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>-0.028</td>
<td>0.009</td>
<td>0.001</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>0.027</td>
<td>0.010</td>
<td>0.001</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>0.030</td>
<td>0.010</td>
<td>0.001</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>0.047</td>
<td>0.010</td>
<td>0.001</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>0.038</td>
<td>0.010</td>
<td>0.001</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>0.055</td>
<td>0.010</td>
<td>0.001</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>
```

One axis accelerometer FFT

Save log and plot on .xls format
Dedicated GUI through STEVAL-IDP004V1

STEVAL-IDP005V1 communication based on Master Board

Adapter RS-485 / USB
Optional USB

Axel Peak
Speed RMS
P, T, H parameters

Axel spectrum

STEVAL-IDP005V1

Download the condition monitoring_iol firmware from the STSW-BFA001V1 Demonstration folder

STSW-IO-LINK Firmware package
The GUI is included in the STSW-BFA001V1 utilities folder.

Once installed please follow:

1. Select the right COM
2. Select the port (more nodes can be connected)
3. Click on connect and wait for connection
STEVAL-IDP005V1 GUI

Vibration Analysis

Frequency domain parameters

Time domain parameters

Plot related to nodes 2 and 3 in this example
STEVAL-IDP005V1 GUI

Environmental Monitoring

- Pressure
- Relative Humidity
- Temperature

Nodes 2 and 3 in this example
1. Check the box “Enable Saving To File Sensor X Measures”

2. Click the related square blue button

3. Select the folder path where to store the file, and choose the file name
How to enable Predictive Maintenance
The Predictive Maintenance demonstration project (PredMaint_SVR), inside STSW-BFA001V1\Projects\Demonstrations\Predictive_Maintenance folder, allows programmable vibration thresholds and outputs motor status details coming from time and frequency vibration analysis. The motor status are:

- **Good**
- **Warning**
- **Alarm**

Fix STEVAL-IDP005V1 very close to equipment. It is recommended not use cantilever board fixing.
User can modify the alarm and warning thresholds for Speed RMS, Acc peak and spectral band. It is done in precompiling phase on `MotionSP_Threshold.h` file. Spectral band can be subdivided in 8, 16, 32 or 64 subrange.

Open the PredMaint_SRV project from `STSW-BFA001V1\Projects\Demonstrations\Predictive_Maintenance_SRV` folder to change thresholds and recompile firmware. It is necessary install one of the supported IDEs.
Predictive Maintenance Demonstration FW
Terminal Emulator Data Output

PC Data output displayed are detailed below:

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Time domain Motor Status details for each axis

*** TIME DOMAIN SPEED RMS THRESHOLDS STATUS X-Y-Z ***

<table>
<thead>
<tr>
<th>GOOD</th>
<th>GOOD</th>
<th>GOOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.325</td>
<td>2.649</td>
<td>0.597</td>
</tr>
</tbody>
</table>

*** TIME DOMAIN ACC PEAK THRESHOLDS STATUS X-Y-Z ***

<table>
<thead>
<tr>
<th>GOOD</th>
<th>ALARM</th>
<th>ALARM</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.144</td>
<td>17.187</td>
<td>7.279</td>
</tr>
</tbody>
</table>

Status on spectral band for each axis in 8 subranges

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General Motor Status in Time and in Frequency domain

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Next Measurement

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STI
Thank you